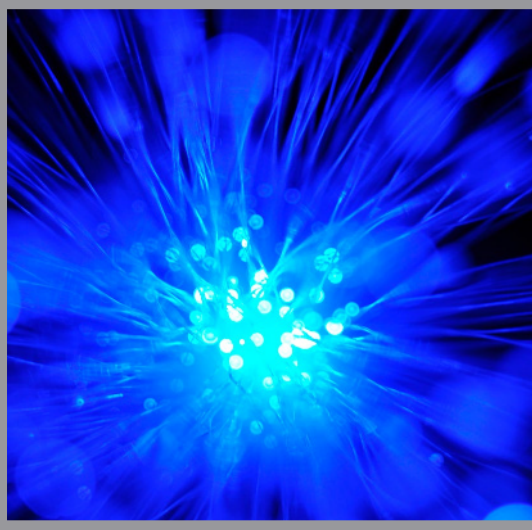
PAS 10412:2015

Intelligent clothing – LED active high visibility clothing – Specification



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Contents

Foreword

This PAS was sponsored by the Taiwan Textile Research Institute (TTRI). Its development was facilitated by BSI Standards Limited and it was published under licence from The British Standards Institution. It came into effect on 30 November 2015.

Acknowledgement is given to the following organizations that were involved in the development of this PAS as members of the steering group:

- Taiwan Textile Research Institute (TTRI)
- AiQ Smart Clothing Incorporated, Taiwan
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Acknowledgement is also given to the members of a wider review panel who were consulted in the development of this PAS.

This PAS is not to be regarded as a British Standard. It will be withdrawn upon publication of its content in, or as, a British Standard.

The PAS process enables a specification to be rapidly developed in order to fulfil an immediate need in industry. A PAS can be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

Relationship with other publications

This PAS specifies requirements for high visibility clothing conforming to EN ISO 20471 incorporating active lighting via Light Emitting Diodes (LEDs).

It is envisaged that further standards for clothing incorporating active lighting will be developed in the future. These might include other types of technology or other forms of clothing.

Product certification/testing. Users of this PAS are advised to consider the desirability of third-party certification/testing of product conformity with this PAS. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Test laboratory accreditation. Users of this PAS are advised to consider the desirability of selecting test laboratories that are accredited to EN ISO/IEC 17025 by a national or international accreditation body.

Assessed capability. Users of this PAS are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the EN ISO 9000 series by an accredited third-party certification body.

Use of this document

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this PAS are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in italic type, and does not constitute a normative element.

Requirements in this PAS are drafted in accordance with *Rules for the structure and drafting of UK standards*, subclause **J.1.1**, which states, "Requirements should be expressed using wording such as: 'When tested as described in Annex A, the product shall ...'". This means that only those products that are capable of passing the specified test will be deemed to conform to this PAS.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a PAS cannot confer immunity from legal obligations

Particular attention is drawn to the need to be aware of regulations and legal obligations that might be applicable to the scope covered by the PAS or compliance with it. Regulations and legal obligations might vary from one country and jurisdiction to another. Particular attention is drawn to those regulations and legal obligations that address Personal Protective Equipment (PPE), where applicable, though it is important to note that the scope of this PAS is not limited to PPE.

Introduction

This specification has been sponsored by the Taiwan Textile Research Institute and developed in conjunction with BSI to cover requirements for high visibility clothing which incorporate active lighting in the form of LED lighting fixtures. Such clothing can be used for visually signalling the presence of the person wearing the clothing to others, especially in situations where there is no, or only limited, external sources of light.

There are many benefits to incorporating LED active lighting in high visibility clothing. The low energy requirements of LEDs mean that they remain an energy effective and cost efficient form of lighting. The low voltage used by the LEDs also pose a low risk to those wearing the LED active high visibility clothing. Their size, relatively light mass and durability allow for flexible and innovative designs that might be used for clothing falling within the category of PPE, or other clothing categories (such as for sport or recreational use) in which visibility is desirable or of key importance. Where clothing does fall within the category of PPE, it is critical to stress that such clothing might fall within the remit of legislation or country-specific regulations which could place certain requirements or restrictions on the design and placement of the LED lighting fixtures. Such requirements fall outside of the remit of this PAS. The intention behind the creation of PAS 10412 is for LED active lighting to enhance and not reduce or restrict the performance of the high visibility clothing within which it is featured.

LED active high visibility clothing is beginning to be used by the traffic police within Taiwan, and a number of other countries. There also exists the potential for such clothing to be used within other situations in which the usability of high visibility clothing could be improved by the addition of active lighting through LEDs.

Intelligent clothing is a new and rapidly developing area within the industries of textiles and technology. In order to establish acceptable levels of the quality and safety of LED active high visibility clothing for the end users of such products, and also to maintain the integrity of manufacturers working in this area, it is necessary to develop standards that can be used to provide an international benchmark against which products can be measured. PAS 10412 has been developed specifically for the purpose of creating requirements and establishing a baseline standard for LED active high visibility clothing.

It is envisaged that further standards for clothing incorporating active lighting will be developed in the future.

1 Scope

This PAS specifies requirements for high visibility clothing conforming to EN ISO 20471 incorporating active lighting via Light Emitting Diodes (LEDs). It covers LED modules that are permanently attached to high visibility clothing. It is applicable to an LED lighting fixture having a removable battery-controller set and LEDs measuring between 2 mm and 20 mm in diameter.

This PAS covers high visibility clothing that is designed to be subjected to temperatures falling between -30°C and 50°C and is applicable to high visibility clothing used in professional or civil situations. It covers requirements for the luminous intensity of the LED lighting set only, when not including luminous intensity obtained from other lighting or visibility systems that also appear on the high visibility clothing, such as fluorescent material and retroreflective material.

This PAS does not cover the requirements of the wiring, e.g. electrically conductive material that is woven into the fabric itself, or fabric made of electrically conductive material. The PAS makes no provision for requirements for LED active high visibility clothing designed for use in fire-fighting, or for protecting against chemical, bio-nuclear, or radioactive situations. It does not cover requirements for the placement or configuration of LED lighting sets on high visibility clothing.

Annex A covers requirements for test specimens and test conditions and Annex B covers a test method for an LED lighting fixture photometric measurement.

NOTE 1 *The temperatures to which the clothing is designed to be subjected includes temperatures expected for cleaning and maintenance of the clothing.*

NOTE 2 *Requirements for fluorescent material and retroreflective material can be found in EN ISO 20471.*

NOTE 3 *Factors related to risk level are given in EN ISO 20471:2013, Table A.1.*

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 60086-5 (IEC 60086-5), *Primary batteries – Part 5: Safety of batteries with aqueous electrolyte*

EN 60529:1992+A2:2013 (IEC 60529:2011), *Degree of protection provided by enclosures (IP Code)*

EN 60598-1:2015 (IEC 60598-1:2014), *Luminaires – Part 1: General requirements and tests*

EN 60598-2-20 (IEC 60598-2-20), *Luminaires – Part 2-20: Particular requirements – Lighting chains*

EN ISO 6330:2012, *Textiles – Domestic washing and drying procedures for textile testing*

EN ISO 13688:2013, *Protective clothing – General requirements (ISO 13688:2013)*

EN ISO 15797, *Textiles – Industrial washing and finishing procedures for testing of workwear*

EN ISO 20471:2013, *High visibility clothing – Test methods and requirements (ISO 20471:2013)*

3 Terms and definitions

For the purposes of this PAS, the terms and definitions given in EN ISO 20471:2013 and the following apply.

3.1 active lighting

visible illumination produced by the flow of electrical current

3.2 battery-controller set

unit incorporating battery source and lighting controls that attaches to, and detaches from, the LED module (see **3.7**)

3.3 high visibility clothing

warning clothing (see **3.9**) intended to provide improved visibility in conditions where the risk of not being seen is high

[EN ISO 20471:2013, **3.1**]

3.4 intelligent clothing

wearable garment that incorporates electronic and/or digital components that provide the person wearing it with a particular benefit, service, or solution to a problem

3.5 LED active high visibility clothing

high visibility clothing (see 3.3) incorporating LED lighting, providing the wearer with improved visibility in situations in which the risk of not being seen is high

NOTE 1 *Information regarding risk levels is given in EN ISO 20471:2013, Table A.1.*

NOTE 2 *The term "improved visibility" is referred to in EN ISO 20471:2013 as "improved conspicuity".*

3.6 LED lighting fixture

lighting unit comprising LED module (see **3.7**) and a battery-controller set (see **3.2**)

3.7 LED module

unit comprising more than one LED with a conductive thread

3.8 passive lighting

fluorescent material, retroreflective material, or a combination of both

3.9 warning clothing

clothing incorporating passive lighting to provide improved visibility in conditions where the risk of not being seen is high

4 High visibility clothing

The high visibility clothing forming part of the LED active high visibility clothing shall conform to EN ISO 20471 and the size designation given in EN ISO 13688:2013, Clause **6**.

NOTE *EN ISO 20471 covers requirements such as for the material and fabric of the high visibility clothing. EN ISO 13688 covers size designation.*

5 Attachment of LED module to high visibility clothing

The LED module shall be permanently attached to the high visibility clothing (see Clause **4**), such that it can be seen from all sides and it can withstand the relevant ageing and exposure tests given in Clause **7**.

NOTE 1 *One example method of attaching the LED module to the high visibility clothing is through sewing.*

NOTE 2 *It is advisable for manufacturers to use an LED module design on the LED active high visibility clothing that covers the full circumference of the torso of the high visibility clothing wearer with LEDs.*

6 LED lighting fixture

*COMMENTARY ON CLAUSE **6***

It is advisable that the ability of the LED module to retain a high level of light emission is also tested. It is recommended that the LED is able to remain at 95% of the rated lumen maintenance life when tested over a period of 1000 h. It is not the purpose of the PAS to describe how this can be tested; there are a number of industry test methods that might be used. One such example is IES LM-80-15 [1].

Note that different countries might have different legislative requirements towards lighting hues, also towards signalling. One example is the use of colour (e.g. the front of a person could be indicated by white coloured lighting while the back of a person could be indicated by red coloured lighting) which might need to be taken into account.

6.1 LED lighting fixture luminosity

When tested in accordance with Annex A and Annex B, the LED lighting fixture photometric measurement shall be a minimum of 0.5 cd (candle).

6.2 LED lighting fixture safety

The LED lighting fixture shall conform to EN 60598-1:2015 (IEC 60598-1) and EN 60598-2-20 (IEC 60598-2-20).

NOTE *It is advisable to give consideration to the potential photobiological impact of LED lighting used in high visibility clothing and to mitigate any potential risks. Further information and guidance can be found in EN 62471/IEC 62471 and IEC/TR 62778.*

6.3 Heat emitted by LED module

The heat emitted from the LED module shall not exceed 37 °C, when tested in accordance with EN 60598-1:2015 (IEC 60598-1:2014), **12.4.1**.

7 LED active high visibility clothing performance – ageing and exposure

7.1 Ageing

*COMMENTARY ON **7.1***

In order to test the durability against wear and ageing of an LED module in real-life conditions as part of a piece of high visibility clothing, it is important to conduct a washing and drying test. The test specimen should consist of the high visibility clothing and the LED module attached to the high visibility clothing as it would be worn. The battery-controller set is not included in this test and should be removed from the high visibility clothing prior to testing. It is important to test in accordance with the manufacturer's washing instructions.

In the previous edition of EN ISO 6330, EN ISO 6330:2000+A1:2008, test method 4N was referenced as test method 5a. Many in the industry still refer to it as test method 5a.

The test specimen shall conform to Clause **4**, and an LED module attached in accordance with Clause **5**.

As applicable to the test specimen and the manufacturer's instructions, the test specimen shall be washed and dried in accordance with either:

- EN ISO 6330:2012 (E), Table B.1, test method 4N, for a total of 5 washing cycles and EN ISO 6330:2012 (E), **10.1.2**, procedure B, for a total of five drying cycles; or
- EN ISO 15797, for a total of 5 washing and drying cycles.

The test specimen shall subsequently continue to conform to Clause **6**.

7.2 Exposure to temperature variation

A test specimen conforming to **A.1.1.** shall be exposed continuously to a cycle of changing temperatures, as follows:

a) for 12 h at (50 ±2) °C; immediately followed by

b) 20 h at (-30 ±2) °C; and

c) conditioned for at least 2 h in accordance with **A.1.2.**

The test specimen shall be tested in accordance with, and conform to, **6.1**.

7.3 Rainfall

A test specimen conforming to Annex A shall be tested in accordance with EN ISO 20471:2013, Annex C.

The test specimen shall subsequently be tested in accordance with, and conform to, **6.1**.

8 Battery-controller set

8.1 Performance

The battery-controller set shall conform to EN 60086-5 (IEC 60086-5).

8.2 Water-resistance

When tested in accordance with EN 60529:1992+A2:2013 (IEC 60529:2011), **14.2.5**, the water resistance grading of the battery-controller set shall be a minimum of IPX5.

9 Marking and product information

9.1 Marking

The product marking shall conform to EN ISO 13688:2013, Clause **7**.

NOTE *The number next to the graphical symbol indicates the clothing class in accordance with EN ISO 20471:2013, Annex A.*

9.2 Product information

The manufacturer shall provide the following information:

a) the name and/or identification mark of the manufacturer;

b) the week or month and year of manufacture (coded or not coded);

c) the number and publication year of this PAS, i.e. PAS 10412:2015; [1)]

d) markings relating to the intended application and use;

e) instructions for product usage;

f) washing and/or cleaning instructions;

g) warnings against problems likely to be encountered, e.g. "the battery-controller set shall be removed before washing".

NOTE *It is advisable for the manufacturer to provide information regarding end of life use of the product, including methods of disposal and recycling, if applicable.*

[1)] Marking PAS 10412:2015 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of this PAS. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Annex A (normative)
Test specimens and test conditions

A.1 Test specimen

A.1.1 General

Each test specimen shall comprise an item of high visibility clothing in accordance with Clause **4** and, either an LED module conforming to Clause **5,** or an LED lighting fixture, as applicable to the test.

A.1.2 Conditioning

The specimen shall be conditioned for at least 24 h at (20 ±2) °C and (65 ±5) %RH. The test shall begin within a 5 min period after withdrawal from the conditioning environment.

A.2 Test conditions

Tests shall be carried out at an ambient temperature of between 20°C and 30°C.

Annex B (normative)
LED lighting fixture photometric measurement

B.1 Principle

A photometer is set up on a photometer holder. A test specimen is placed on a half-man mannequin or equivalent, which is set up on a goniophotometer at a measured distance from the photometer. All light sources, except for that emitted by the LED module, are turned off and all light-diffusing objects removed. The LED lighting fixture is left to stabilize for a minimum period of 3 min and the individual LEDs checked to be working. Once the light has stabilized, the photometer is set to measure the light intensity when rotating upwards and downwards at an angle of 3° and horizontally, left to right, at an angle of 90° (which is an angle that receives the minimum light intensity from the LED module). The results are recorded.

NOTE *The principles for testing for angles of light distribution used within the United Nations Economic Commission for Europe Regulation 7 [2] have been used to inform the development of this test method.*

B.2 Apparatus

B.2.1 *Half-man mannequin or equivalent*, capable of holding the test specimen.

NOTE *A "half-man mannequin" is often referred to as a "torso". An equivalent type of mannequin might be used for types of clothing under test such as trousers which would not fit on a half-man mannequin.*

B.2.2 *Goniophotometer*, having a rotation angle to the left/right of 180°(±0.01°) and up/down of 90°(±0.01°).

NOTE *This is also referred to as an "automatic rotary table".*

B.2.3 *Photometer*, having an approximate measurement range of 10^{-5} lx to 2×10^{5} lx.

B.3 Test specimens and test conditions

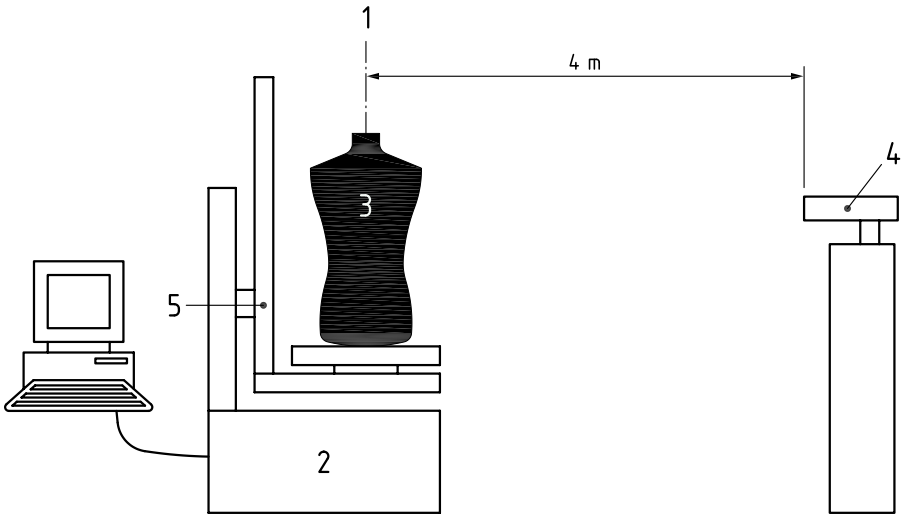
B.3.1 Three test specimens conforming to **A.1** shall be selected for testing.

B.3.2 Test conditions shall conform to **A.2**. Tests shall be carried out in an indoor environment from which all light can be prevented from entering and in which all light sources can be removed or switched off.

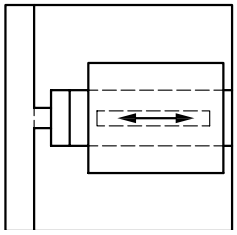
B.4 Procedure

B.4.1 Arrange the apparatus as shown in Figure B.1 and Figure B.2.

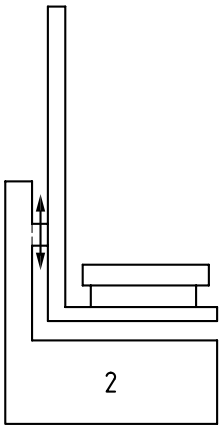
Figure B.1 – Apparatus arrangement for LED lighting fixture photometric measurement



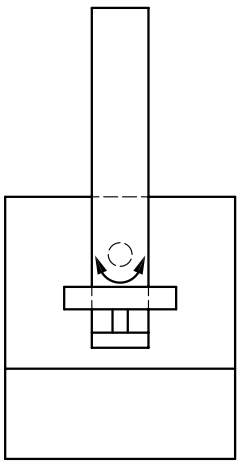
a) Apparatus arrangement



b) Overhead view of test datum plane



c) Movement of goniophotometer

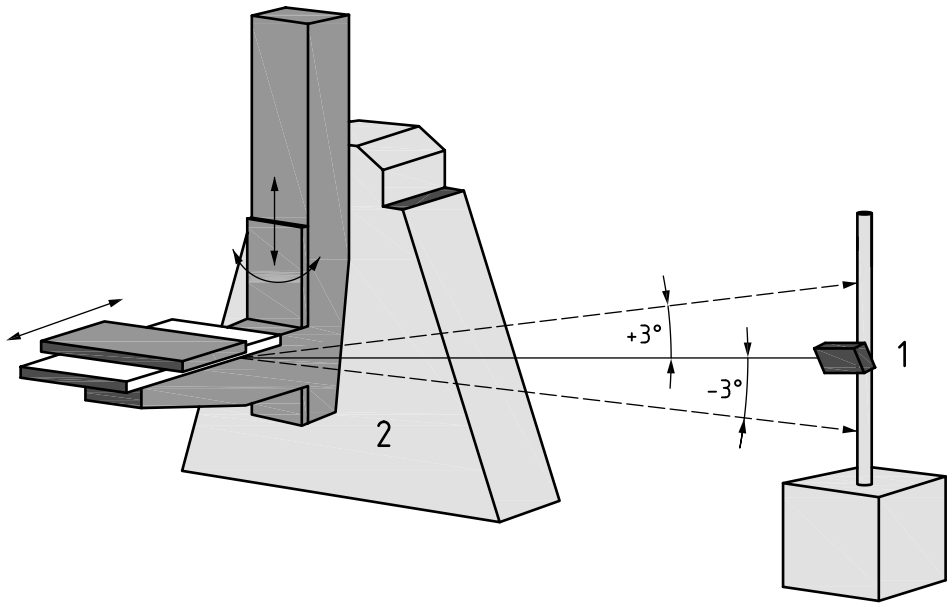


d) Overhead view of movement of half-man mannequin or equivalent

Key

1	Test datum plane	4	Photometer
2	Goniophotometer	5	Laser detector
3	Half-man mannequin or equivalent		

Figure B.2 – Photometer placement and rotation



Key

1	Photometer	2	Goniophotometer

B.4.2 Place the test specimen on a half-man mannequin or equivalent on the rotary table of the goniophotometer (Figure B.1, key 2; Figure B.2, key 2). Mount the photometer at a distance of 4 m away from the half-man mannequin or equivalent and at an angle from which the geometric centre of the test specimen can be located. Turn the laser positioning switch on, and locate the geometric centre of the test specimen.

B.4.3 Turn on the LED lighting fixture with rated current.

B.4.4 Turn off all indoor light sources and remove all objects from the test environment that are capable of diffusing light.

B.4.5 Allow the brightness of the LED lighting fixture to stabilize for a period of 3 min.

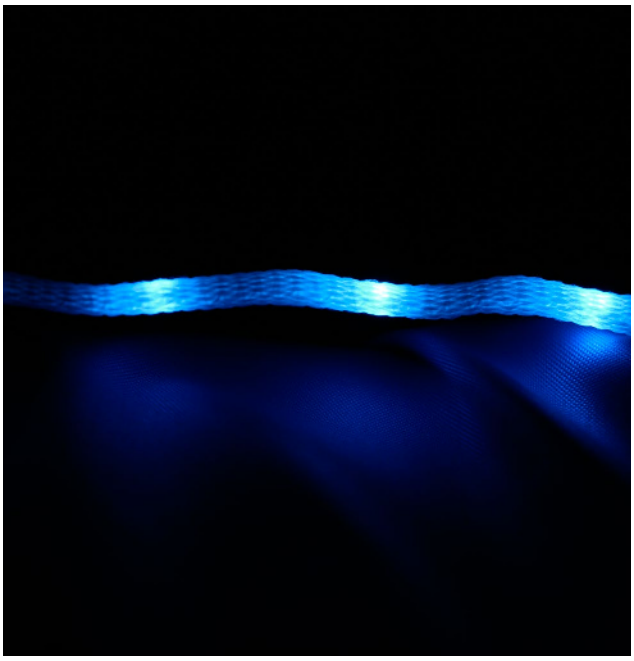
B.4.6 Check that the individual LEDs are working. If any of the LEDs are not working or the brightness level does not stabilize, stop the test and record the test as a failure.

B.4.7 Set the rotary table of the goniophotometer to perform a rotation upwards and downwards at an angle of 3° and horizontally at an angle of 90°, before proceeding to the maximum light intensity measurement for the LED module.

B.4.8 Repeat the test until all of the test specimens (see **B.3.1**) have been tested.

B.5 Expression of results

Record the minimum light intensity of each of the test specimens in candle (cd).



Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 62471/IEC 62471, *Photobiological safety of lamps and lamp systems*

EN ISO 9000 (series), *Quality management systems*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

IEC/TR 62778, *Application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires*

Other publications

[1] ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICAN TESTING PROCEDURES COMMITTEE. *IES approved method: Measuring luminous flux and colour maintenance of LED packages, arrays and modules (IES LM-80-15)*.

[2] UNITED NATIONS. UN vehicle regulations – 1958 agreement. Economic Commission for Europe Regulation 7. E/ECE/324/Add.6/Rev.6/Amend. 3. Agreement concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions. Revision 2, including the amendments which entered into force on 16 October 1995. Regulation No. 7 (including addendum 6, amendment 3). Uniform provisions concerning the approval of front and rear position lamps, stop-lamps and end-outline marker lamps for motor vehicles (except motor cycles) and their trailers. Geneva: UN, 2014.[2)]

[2)] At the time of publication, this document is downloadable from the following website: http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/updates/R007r6am3e.pdf.

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